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On the Progress of the North American Carboniferous Flora, in preparation for the Second Geological Survey of Pennsylvania.

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(*Read before the American Philosophical Society, January 5, 1877.*)

The purpose of this memoir is to give a short account of the progress which has been made, to this day, in the preparation of the North American Coal Flora as one volume of the current Reports of the Second Geological Survey of Pennsylvania.

At first it seemed appropriate to prepare for publication, and in order to preserve the right of priority of names, a catalogue of the species which have to be described in the Flora, and to define the essential points of the classification, especially the generic divisions.

Details of classification, however, cannot be positively fixed before all the materials used in the preparation of the descriptions of the species have been definitely examined. Then the manuscript of the flora will be ready for the printer and a synopsis of it would be useless. Moreover, a mere enumeration of names would offer little of general interest.

It is therefore more advisable to give in advance an *exposé* of the plan which has been followed in the researches deemed necessary for the preparation of the work ; of the available sources of information ; of the materials, when and where collected for it ; of the point arrived at until now, and, therefore, of the more interesting data which have to be exposed in the publication of this Flora.

Those who have ever examined what is generally called specimens of coal plants, know that they generally represent parts of trunks, whose surface is marked by peculiar impressions; or branches without leaves, whose relation is recognized also by the scars upon their bark; or, for the ferns, especially, fragments or pinnæ of fronds with leaflets, or more generally, of detached pinnules, which, though they may be beautiful, do not give, when considered separately, an idea of the general or true character of the vegetable to which they belong. The classification of the living species of the great family of the ferns is derived more especially from the characters of their fructifications. In the coal, though the ferns constitute by far the greatest part of the vegetation, their fructifications are rarely found, and when found, they are mostly attached to branches or pinnæ separated from the sterile fronds, which then, were, as they are now, often very different in aspect and characters from the fruiting ones. Hence it is very difficult to ascertain their correlation ; and thus the paleobotanist may place in one genus a sterile branch when he has to describe the fertile pinna of the same fern, in another. Long ribbon leaves, hard fruits of various shape, also are frequently seen in the shale of the coal ; but these are most rarely, if ever found attached

to stems, and, therefore the relation of many of them to the plants which they represent prevents their reference to original types, and forces, for their description, an artificial classification which the discovery of a single specimen may overthrow. Hence it happens that, in the pursuit of his researches to recognize the specific characters or even the more distant relations of the vegetable fragments, the paleontologist is forced to look for and to compare a large number of specimens before he is able to fix their references. The subdivisions of the leaves or fronds of ferns, the pinnæ and pinnules, have not between the same species that kind of likeness or affinity of shape remarked between the leaves of dicotyledonous plants. The modifications of form are not only extremely numerous, but present such an anomalous diversity, that botanists unacquainted with this section of natural history could often suppose no generic relation between some of the leaflets which represent the same species. One of the most common ferns of the middle coal measures, a *Neuropteris*, for instance, is nearly always found in detached, fine, large, cordate-lanceolate leaflets, which sometimes measure four to five inches in length and two or three inches in diameter. Some small round or broadly oval pinnules are generally found mixed with those large leaves; they are not even half an inch in diameter; and though they have a similar character of nervation, the difference in shape and size is so marked that they were of course described under a different specific name. Lindley and Hutton were the first to suppose, from their coincidence of local distribution, that they might possibly represent parts of the same plant. Since then, and long afterwards, large branches of fronds have been discovered in this country with the two forms of leaves attached to the same pedicel, the large leaves being borne upon a short stalk, with two small leaflets attached to their base. A number of cases of the same kind might be mentioned; but this one is sufficient, and I quote it not merely to show how great are the difficulties encountered by the botanist in the study of coal plants and what persistence it demands, but to prove that the discoveries made in the coal flora of this continent render now to European paleontologists the same amount of assistance that we have received from their works in former times.

The remains of coal plants, generally pleasant to the eye by their graceful shape, and some of them of very peculiar forms, widely apart from those which are generally observable in the vegetation of our time, could not but, as wonderful productions of nature, excite the interest of the first investigators of the carboniferous measures of Pennsylvania. Already in 1818, Steinhauer had published in the Transactions of the American Philosophical Society his *Fossil reliquia*, where remains of plants now referable to *Calamites*, *Lepidodendron*, *Ulodendron*, *Artisia*, *Sigillaria*, and *Stigmaria*, are figured and described under the collective name of *Phytolithes*. He does not represent any kind of fern; but he mentions in the introduction that most of the specimens of fossil plants from the carboniferous are *Filices* (ferns). After him, in 1820, Granger mentions without descriptions a few specimens of coal plants from Zanesville, Ohio. From that time

to 1828, Granger, Cist and Professor Silliman sent a number of specimens to Brongniart, who was then engaged in the publication of his great work upon the flora of the coal. In 1831, Professor Eaton described with figures a fossil scale tree, (*Lepidodendron*), sent to him from Montrose, in Bradford County, Pennsylvania.* In 1833, the same author remarks that Professor James Hall had made in Pennsylvania the most extensive collection of vegetable fossils that had hitherto been made on this continent, and gives the names of six species which had been determined by the aid of Brongniart's figures and descriptions, adding that he had before him twenty-five ascertained species from the coal measures of Pennsylvania. Already in 1831 the description of *Fucoides Brongniarti* was published by Harlan, who had discovered it and mentioned it before as *F. Alleghaniensis*. This species was later redescribed by Hall in Pal. of New York, as *F. Harlani*, and later still Göppert, in his Flora of the Transition measures, rendered a just tribute of homage both to Harlan and to Hall in describing it anew as *Harlania Hallii*. I find in the same historical record of Professor Lesley, mention of a splendid collection of coal plants made at great expense and presented to the Geological Society of Pennsylvania by Dr. Martin. This collection, it seems, has been lost. Then, of a plate of fossil plants of the New Red of Virginia, by Mr. F. G. Clemson; farther on, a paper by Harlan on coal plants, four species of which are figured; and later still, some remarks from the same naturalist upon a species of *Equisetum* referable to *Asterophyllites* or *Annularia*. To this I may add the record of a memoir published in 1837 by Dr. Hildreth, in Silliman's Journal, where this able geologist and noble man has figured a number of coal plants, mostly undescribed and without names, some of them of indefinite relationships; and of another memoir published in 1847 by Dr. Tschmachner of Boston, who mentions twenty-three species of coal plants from Massachusetts and Rhode Island, some of them figured, and more or less distinctly referable to species known from the works of European authors. For, at that time, the coal flora of Europe had been already studied with great activity, and besides the works of the older authors, Schlottheim, Artis, Lindley and Hutton, Sternberg, which have lost nothing of their scientific value even to our time, the paleobotanists of America had for points of comparison of their fossil plants the Flora of Brongniart, and his numerous memoirs on coal plants published from 1821 to 1844; a pamphlet of Berger on the fruits of the coal; Corda's Beiträge, a splendid work on the internal structure of fossil trunks and stems; Germar's work on the fossils of the carboniferous of Wettin; Göppert's Systema, 1836; and later, his genera (Gattungen), published from 1841-48; Gutbier; Unger on the *Calamites*; and less important memoirs of authors, Binney, Geinitz, Schimper, Roemer, etc., who have now become far-famed by notable works on the vegetable paleontology of the coal.

From this rapid synopsis it may be seen how little was known of the carboniferous flora of North America when, in 1851, I was called to join the

* I quote this and the following data from Professor J. P. Lesley's historical sketches, as I have had no access to the mentioned memoirs.

corps of the first Geological Survey of Pennsylvania as Paleobotanist, and was then requested, not merely to collect and study the coal plants, and to give an account of them, but to find in regard to their stratigraphical distribution some data which might be of application for the determination of the relative position of the coal beds. I went to work then ; but when I look now upon those first researches of mine, I can but feel a deep sense of commiseration for that student of American paleobotany who had never before seen an American specimen of fossil plants, and who was called to prepare a full record of a flora which after twenty-five years of incessant work is as yet, and will ever be, incomplete ; and to decide upon problems as far from solution now, after the multiplied researches of a score of naturalists of the highest standing, as they were thirty years ago. And this commiseration does not apply merely to the results of the work, but to the labor itself. I had as yet never had any collection of coal plants of my own, and thus had no points of comparison whatever. I had merely studied these plants in some of the more important cabinets of Europe, especially that of Strashourg, which had furnished to Brongniart a large part of the materials used for his Flora. And, except a copy of Sternberg lent to me by the director of the survey, I had no books. The work had to be done, however. Spending days, even whole weeks, upon the great heaps of black shale, now such a marked feature of the landscape of the Anthracite fields ; cutting and turning over those shales, sometimes heated by the sun to such a degree that they could hardly be taken into the hands ; comparing incomplete fragments in trying to recognize the original characters of the plants ; carefully collecting all that seemed of any value to my purpose, and heaping and transporting lots of specimens on my back, however great the distances might be, I had soon materials enough at my command. For then most of the mines were new openings ; the shales were generally taken out, and lay uncovered, and some of the coal beds were very rich in fossil remains. Moreover, I found already some fine cabinets of fossil plants open to me for examination ; that of Mr. Clarkson of Wilkesbarre ; of Mr. Jones of Carbondale, both very intelligent gentlemen, superintendents of coal mines ; and many fine specimens, isolated as curiosities by hotel keepers or land proprietors, were presented to the survey. All these specimens after being examined and labeled by a No. of order corresponding with those of my book of references, in which remarks on the specification were written, were boxed and sent to the address of Professor Rogers at Philadelphia ; except, however, those which had to be figured for the plates of the report, or which as yet, of uncertain relation, had to be more carefully studied.

At the suggestion of the director of the survey I had prepared for publication in the Boston Journal of Natural History (August, 1854) an abridged description of the new species of fossil plants found in the coal fields of Pennsylvania. But the final report was mostly made at the house of Prof. Rogers at Boston, where all the specimens of the survey were then, and where I spent three months in a final review to close the memoir

on the fossil flora of the coal. When I delivered it, it was with the understanding that I should have the privilege of reviewing the manuscript before it was delivered to the printer, or at least of correcting the galley-proofs. But I heard nothing more about it, nor a word from Prof. Rogers; and thus I supposed that the publication of the report had been abandoned; when I received, in 1858, a printed copy of the plates, with a note requesting me to correct them if I found it advisable, and stating that the report was already definitely printed. Of course, as I had no copy of the manuscript, nor any proof prints, I could not correct the plates, which are moreover satisfactorily engraved. It is not necessary to say that if I could have reviewed the memoir before its publication it would have been, if not re-written entirely, at least greatly modified; for after some years of further researches for specimens of coal plants in the Pennsylvania anthracite fields, I should have had some important corrections to make and a number of interesting data as additions to it. For indeed its phraseology is very poor, the descriptions incomplete, and some of the species incorrectly named; the orthography of the Latin names especially is abominable; but as it is the same for the nomenclature of Prof. Rogers, the printer is accountable for the defect. Even on the subject of incorrect determinations of species little has been criticised of the memoir by European authors, and the continued examination of a great number of specimens up to this time has confirmed them with few exceptions. *Asterophyllites ovalis* and *crassicaulis* are fruiting branches now referred by some botanists to *Annularia*, by others to *Sphenophyllum*, by myself still to *Asterophyllites*. The characters of these remains are now known by specimens as complete as may be obtained of petrified vegetable organisms; their relation is, however, not determined upon, and is still in discussion among European authors. *Alethopteris obscura*, of which a mere fragment, seemingly far too incomplete for satisfactory determination, is represented Pl. I, was later discovered at the same locality, in whole pinnæ, which show the same characters and relation as marked in the first description. *Cyclopteris* (*Neuropteris*) *fimbriata* has not only been found at different places, especially in Illinois, always representing the characters originally ascribed to it, but even Prof. Heer, who, when the species was first published, considered it as an imaginary or abnormal representation of leaves of ferns, has it now from the anthracite measures of Switzerland, and has described two species remarkably similar to or perhaps identical with it. The splendid *Neuropteris Rogersii* has been found again in many specimens, at the same and only locality where it had been originally discovered, preserving its identity of characters. Another specimen also has been obtained of the queerly branching *Sphenopteris Newberryi*, with the same peculiar forking of its pinnæ. And the *Lepidodendron* species, though multiplied too far according to Schimper, have been studied from an immense number of specimens from the lower plant bearing strata of the whole extent of the North American coal measures, and their specific characters have been found persistent upon large trunks and upon small branches, therefore with

the scars of very different size. Some corrections have to be made, as said above, but certainly not more than would be demanded for a work of this kind, pursued under the most unfavorable circumstances, twenty years after its publication.

After the close of the survey or of the exploration under the direction of Prof. H. D. Rogers, I had continued, on my own account and at my own expense, the explorations for the study of the coal plants of the anthracite fields of Pennsylvania. In the fall of 1857, while stopping at Pottsville for the examination and determination of a large lot of specimens of fossil plants in the cabinet of the Pottsville Scientific Association, I was requested by some members of the society to prepare a catalogue of all the species which had come under my examination in Pennsylvania and other States, including the species which I had then recognized in the Pottsville cabinet. This catalogue, delivered February 1858, was immediately published. It comprises the names of 286 species, including those copied from a list of the species of coal plants from Ohio by Dr. Newberry. Most of the species described in my report to Prof. Rogers are named, and form the largest part of it; some however being left out as uncertain, others added and described and figured as new. No reference is made in this catalogue to the Pennsylvania Geological Report for the good reason that I did not know if this report should ever appear in print. But as the new species described in it had been already published, and their names were thus public property, and as the others were those of species described by European authors, I was then and am now still unable to see how the publication of this catalogue could be considered as a breach of literary obligation, according to the expressions of the Pennsylvania report, p. 878. It is certainly needless to say any more on the subject.

I had at that time become acquainted with the fossil flora of the Pennsylvania coal measures quite as sufficiently as I thought needful for my purpose, and I was anxious to pursue the exploration in other coal fields in order to be able to study the characters of the vegetation of the coal at distant localities, for the elucidation of more important questions, those especially referable to the geographical and stratigraphical distribution of the species at the carboniferous period. For it would not do to attempt to expose a history of the American coal flora merely from data obtained in Pennsylvania. With this idea I began a new series of field explorations, and the examination of all the collections of fossil plants to which I could gain access; and this work has been pursued nearly uninterruptedly until now. First I went, twice, along the Ohio river from Pomeroy down to Gallipolis, and up the Kenawha river to the salines of Charlestown, Virginia. I had then the opportunity to see the cabinet of Dr. Hildreth at Marietta, and to begin with this justly venerated geologist a series of relations and mutual communications continued to his death. At Charles'own I had access to a fine cabinet of specimens of the Rev. Mr. Brown, who had a number of interesting and new species. I collected myself good material for study in the mines worked then above that place. I visited the more interesting

portions of the coal measures of Ohio ; twice the mines of Cuyahoga Falls ; those along the railroad from Cleveland to the mouth of Yellow creek ; the coal strata under the Flint ridge near Newark ; those of Zanesville. and down the Muskingum river, thus passing over the coal fields in various directions.

I had been before to Nashville to see Professor Troost and his celebrated cabinet of mineral specimens, which had then scarcely anything referable to vegetable paleontology. I found later, however, at Lebanon, in the collections of Prof. Jas. M. Safford, State Geologist of Tennessee, a fine lot of remarkably well preserved impressions of ferns, with some hard fruits, *Carpolithes*, *Trigonocarpes*, some of them new species.

These private researches becoming too expensive for my very limited means, and also too little productive in results of importance to my researches, I readily accepted the proposition of Dr. D. D. Owen, to join his corps of assistants on the Geological State Survey of Kentucky, and gave to the work two or three months each year. These explorations were of little account, and did not afford any valuable discoveries in vegetable paleontology. For except the coal beds of the upper stage, worked for the use of steamboats along the Ohio river, and which had no fossil remains of plants, most of those exposed inland were then unopened for want of communications, and thus I had rarely any opportunity to get good specimens.

The results of the geological *reconnaissance* in Arkansas, under the same direction, were far more valuable and interesting. But here, again, it was impossible to stop at peculiar places for prolonged investigation for fossils. So hurried were the explorations made, with the necessary incumbrance of a camp, that for the examination of the finest exposition of a coal, that of Malés, where there was an abundance of specimens, we had scarcely one hour of time. This exposure was at the top of a mountain where no water and no feed could be got for the horses, and arriving at the mines late in the evening when it was already nearly dark, we had to leave at daybreak, and thus was lost the only good opportunity I had to compare the characters of the sub-carboniferous flora of that State with those of the true carboniferous of the Eastern basins.

The specimens hastily secured in that short time, however, proved very valuable ; for if they did not represent a number of species sufficient for a determination of the general character of the vegetation, they showed mostly new types, as may be seen in the second volume of the Arkansas Geological Report, where they have been described and figured in five plates.

My next explorations in connection with the Geological State Survey of Illinois were, per contra, very productive in valuable discoveries in relation to the flora of the coal. The very able chief of the survey, A. H. Worthen, then gave not only to the direction of the work the greatest energy, looking for every possible opportunity of examining himself the coal strata whose station was still uncertain ; but whenever we had chances of obtaining fossil remains he gave me sufficient time and his own assistance for

collections which, transferred to the large State cabinet of Springfield, were afterwards examined and determined at leisure. Some localities, like that of Morris, Grundy county, for example, where the vegetable fragments are preserved both in soft shale, and in very hard concretions, afforded a rare opportunity for the study of a local distribution of the coal flora and also of a remarkable exposition of its richness and luxuriance. For the concretions there hold in preservation some of the small and soft vegetable remains which are generally destroyed by a protracted maceration in porous materials like shale or sandstone. There were moreover at Morris some private cabinets of gentlemen interested in fossil botany by the beauty of the specimens obtainable in the vicinity, those of Jos. Even, S. S. Strong, Prendel, Armstrong. These were kindly opened for my examination, and afforded abundant materials for study. The essential results of the paleobotanical explorations in Illinois are exposed in the second and fourth volumes of the Geological Reports of that State, and their importance may be judged by the table of species, Vol. IV, p. 471, whose number amounts to two hundred and twenty-six, a number which has been greatly increased since then. Some of the species recognized in the flora of Morris are extremely interesting, remarkable indeed for characters which had nowhere been recognized until then in the vegetation of coal, and which therefore might be supposed to be somewhat imaginary or derived from obscure specimens. These, however, like *Neuropteris Verbenæfolia*, *N. pachyderma* of the second volume, have been re-discovered in better specimens, though the first were already satisfactorily determined. And this was the more opportune that the first and only specimens used for exemplification and belonging to Mr. Even had been lost by a fire which destroyed his whole property. This second volume also figures some peculiar species to which is attached a double importance and significance, by their own characters, and by their relations to types generally considered as strangers to the carboniferous formations. Of these I will say something more after finishing the enumeration of the means employed for increasing the amount of materials serviceable for the study of the coal flora.

While occupied with the surveys, I had always, in pursuance of the same plan, looked for every opportunity of examining local collections or encouraging local researches for specimens of fossil plants. The specimens of Amherst College had been entrusted to me for determination. I had seen also those of Yale College, those of Prof. J. D. Dana; determined the species in the cabinet of Princeton College, and established correspondence for exchanges or communications; among others with Mr. T. H. Clark, of Newport, R. I., who had for a long time collected specimens of plants from the coal of Mount Hope, which by and by gave a very interesting contribution to the North American coal flora. More recently a new light was thrown into the obscure question of the vertical distribution of the coal flora and upon the characters of its groups, by the communication of a whole cabinet of fossil plants from the coal fields of Alabama, sent for determination by the Director of that Geological Survey, Prof. Eug. A. Smith.

A mere catalogue of the names has been published in the first volume of his first report, together with a reference to the group or geological division indicated by these plants. The remarks then made on this subject have been confirmed by subsequent communications of specimens from the same coal fields; those of Mr. T. H. Aldrich, proprietor of the Montevallo coal, and of Mr. Thos. Sharp, Superintendent of the Newcastle Company.

Since my connection with the Second Geological Survey of Pennsylvania explorations of the same kind have been pursued with renewed activity, and these have been still more fruitful and more interesting than those of old. They have greatly increased and multiplied the field of researches, constantly adding new materials to those which were at hand, and thus showing how great is the richness of the vegetation of the coal, and how backwards we are yet in our acquaintance with it. We have now a group of fossil plants from Clinton, Mo. which, collected by Dr. Britts in lower carboniferous very productive shale, not only represents many new species, but, taken in the whole, affords a fair point of comparison for the western lower coal measures. Another from the Cannelton Coal of Beaver county, Pa. (Coal C, of Lesley), where M. J. F. Mansfield, the proprietor, has, at great expense of time and money, pursued systematic explorations in the roof shales, which there hold remains of plants in profusion. This local flora will become an important representative of the vegetation of the middle part of the lower carboniferous. Prof. Worthen has sent a lot of plants, some of them of new and remarkable types, from under the Chester Limestone of Western Illinois; and Prof. E. T. Con, another not less interesting from the Whetstone grit of Indiana, which overlies the same sub-carboniferous formation. From the same geologist I have had for determination a number of specimens of fucoids, or remains of marine plants, very remarkable in their typical relations, all discovered in the coal measures of Indiana. Though these do not belong to the Pennsylvania survey, and have been described in the last report of Indiana, they pertain, of course, to the Coal Flora. And more still, we have received from Illinois a lot of specimens from the pseudo-carboniferous, representing plants of the same characters as those discovered by Prof. E. B. Andrews in the Waverly Sandstone of Ohio. This communication is due to Mr. S. H. Southwell, of Fort Byron, Ill. who discovered also at about the same horizon specimens of one of the species of fucoids described in the Indiana report.

Last fall I visited twice the sub-carboniferous coal beds around Sharon and Youngstown, to ascertain the character of their vegetation, and obtained valuable specimens, some of them of new species. I made also a short tour of exploration in the basins of the Swatara river and Raush creek to compare once more the plants of the Mammoth with those of the Salem vein. Besides the specimens found by myself, a number of others were then presented to the Survey by Mr. T. Price Wetherill, of Trement. Mr. W. Lorenz, Superintendent of the Philadelphia & Reading

R. R. directed the researches to the more interesting localities, presented to me all the specimens found by himself, and when I returned to Philadelphia gave me the privilege of examining his cabinet, to select from it all the materials which might be of use to my work.

The last, but not the least, important communication to the Survey is due to Mr. S. S. Strong, of Morris, Ill. I have already remarked upon his cabinet, which was opened for my researches in connection with the Geological Survey of Illinois. Since that time this proficient explorer of vegetable remains has constantly increased his splendid collection, especially from the nodules of Mazon creek. Lately he proposed that I should go to Morris to make a fair review of his specimens and to determine them, offering to the Survey, as a compensation to my work, all those which I should consider as representatives of very rare or new species. This examination has added an important store of materials of great value to those which we had already; and it is evident that by the addition of a number of species of various types, either new or not observed before at Morris, we have in the flora of that locality the best possible point of comparison for geological distribution of the coal flora; while, by its station between the two essential subdivisions of the coal measures, it offers the same advantages for judging of the modifications of the plants in passing from the sub carboniferous upwards.

To close this enumeration of the resources now in store for the preparation of the North America Coal Flora I have still to mention the publications made in this country upon the same subject; for of course this Flora has to take into consideration the materials used in the preparation of these works. The most important ones are the memoirs of Professor J. W. Dawson, of Montreal, who has studied for years the Devonian and lower carboniferous floras of Canada, and of the Western States with a patience and industry which have justly rendered his name famous. After this in degree of importance we have, in the first volume on the Paleontology of the Geological Reports of Ohio, a valuable monography of fruits of the carboniferous by Dr. Newberry. It throws much light upon the true characters of those vegetable remains so rarely found in a good state of preservation, and so difficult to study, especially in regard to their relationships. A number of them had been briefly described, by the same author, in the *Annals of Science*, 1853. The second volume of the same Report is enriched by a memoir of Professor E. B. Andrews, upon species of fossil plants discovered by himself in the formation of the Waverly Sandstone of Ohio. By the precise descriptions and the splendid illustrations of the species representing new typical forms of the vegetation of the coal this memoir is indeed an important contribution to vegetable paleontology. We had had before upon some species of the *Vespertine* of Virginia a too short paper from Professor B. F. Meek, with two fine plates of illustrations, and an accuracy of description which so remarkably characterized this paleontologist who leaves behind him a wide-world repute. This has been followed up by another memoir on the conglomerate series of Virginia, by Pro-

fessor V. Fontaine. No plates are given as illustration of the species; but these are so carefully described that the characters are easily recognized without figures. In connection with Professor I. C. White, these gentlemen are now studying a lot of fossil plants whose discovery is due to Professor John J. Stevenson, but whose specimens were collected by themselves. They represent an upper section of the carboniferous, apparently touching on the Permian. The results of this study which they intend to publish soon, can not fail to add new materials which ought to contribute to the fullness of the coal flora.

From all that has been seen above it is clear that this *Coal Flora*, in preparation for the second Geological Survey of Pennsylvania, is not merely a description with figures of the species of the coal measures of that State. The concentration of such researches within precise geographical limits would deprive them of any importance, and of any scientific value; for the work done in that way would give only a very meagre representation of the vegetation of the coal period, and it is desirable to know it in its whole extent, as far as our acquaintance with it has advanced until now. I purpose, therefore, to consider all the plants found in the coal measures, from the eastern limits of the continent (New Scotia, New Brunswick) to the eastern borders of the coal fields in Kansas. Even farther West, in the Rocky Mountains, a few remains of *Calamites* have been found. They represent merely two species recognized in the Permian as well as in the carboniferous of Europe, and they offer no great interest by their specific characters. They have to be described, however, as serviceable for comparison in case of future discoveries. And considering the vertical distribution of the vegetation of the coal, it is advisable also to give to this flora the widest possible range, and to admit into it all the species of land plants recognized on this continent, from the first appearance of land vegetation in the upper silurian strata, to the end of the carboniferous period. The true devonian species, those which have not yet been observed in the Catskill or Old Red sandstone, now considered as lower carboniferous, are very few in number, not more than half a dozen perhaps. It is probable that similar or related types may be recognized hereafter in the true coal measures. We want to know them, therefore, for eventual comparison. Moreover, they enter into the history of the coal flora as ancestors; and in its records nothing should be omitted which may throw any light into the important question of the development of the primitive types, reappearing under modified characters. I quote a single example as illustration. There is in the coal of Morris a species of *Neuropteris*, with leaflets seemingly branching in an anomalous way, by the splitting of the rachis either at the base or in the middle of the leaflets. This species, described as *Neuropteris fasciculata*, has been considered as a kind of monstrosity or a casual decomposition of the leaflets, as we see sometimes in the living flora. But the same character is seen already in *Megalopteris*, a species of the lowest coal measures; thus we find it continued in that *Neuropteris* of Morris, and thereby have a proof of its persistence from the base to the middle of the carboniferous.

Let me now answer the questions which the above exposition may have suggested. What is the purpose of this work? What are the results already obtained from the researches? What may be expected of its completion? A constantly more intimate acquaintance with the characters of the coal flora is the first and natural result of prolonged and extensive explorations. This will not say, however, that we shall have by this a full history of the vegetation of the coal. For, as it has been remarked in the beginning of this paper, the fossil vegetable remains of the coal are generally mere fragments, which, considered separately, do not show the characters of the whole plants to which they pertain. These can be recognized only by the comparison, sometimes of a large number of specimens; and it may even be said that many of the species of the coal are without any scientific value, for the reason that they are defined by characters which belong to mere fragments. And the deficiency of reliable specific characters apply not only to the coal plants themselves, but become more evident still in the attempts made to fix their relation to the plants of our time.

The insufficiency of the evidence afforded to the student by those mere fragments of vegetables has been complained of by the most sagacious paleontologists, and has discouraged the most ardent followers of Paleobotany. Lindley and Hutton bitterly lament it in their fossil flora of Great Britain, which, however incomplete it may be, has become a classic or leading work, and is now re-edited in its integrity. Hooker, the prince of the botanists of our age, while connected with the Geological Survey of England, makes, in his report, a comparison of the vegetation of the coal with that of our time, and devotes the largest part of it to exemplify by figures and descriptions how rarely fragments of ferns may represent the characters of the species to which they belong. He has, however, in the exposition of the structure of the *Stigmaria* and of *Lepidostrobus*, the fruits of *Lepidodendron*, anatomically studied from silicified specimens, thrown such light on the affinity of those plants, that his too short memoir is considered as the most important on the subject. Brongniart, also a prince among the botanists of his time, spent many years in exploring the coal measures of France and Belgium, in visiting all the museums where specimens of fossil vegetables were preserved, before he began, in 1828, the preparation of his great work on the fossil flora of the coal. Adding to his stock of materials by exchanges and by communications received from the scientific world at large, he pursued his labors until 1844, when he abandoned the work half done. His *Flora* is, however, even now the most reliable guide to the student of Paleobotany. Göppert, too, supposing that from the immense number of specimens of coal plants gathered into his splendid cabinet he should be able to fix a new classification of the ferns of the coal from the characters of their fructifications, began his *Genera (Gattungen)* in 1841, and abandoned it, discouraged, after six fascicules had been published. This work, however, incomplete as it is, has, by the exemplification of the structure of a number of forms of the fructifications

of ferns, directed researches toward this new field of exploration and opened a path which, by and by, enlarged by new discoveries, may afford a more reliable way for the determination of species of this family. Still more recently, Goldenberg attempted a detailed monography of the fossil plants of Saarbruck (*Flora Saræpontana*), where he had found an abundance of valuable materials. Of it he published only three fascicules; but they represent a valuable monography of the *Sigillariæ*, and this also is a gain to the fossil flora.

What conclusions may be derived from this? Shall we say that the coal flora cannot be studied with advantage from a number of specimens observed at peculiar localities? Shall we admit that this flora cannot be studied at all, and that it should be left in its grand and sublime mystery? The first assertion is right; the second rests upon an objection, which may be made against every study, which tends to the interpretation of documents whose writing is as yet imperfectly known. The hieroglyphs of the Pyramids are still more obscure, still farther from exposing a comprehensive record of the history of the people who built them. Some have been deciphered, nevertheless, and a few pages of the writing have thrown a deal of light upon that history and have been accepted by science as a momentous revelation. The history of our earth is not a less important knowledge than that of the races of men who have inhabited it. And how can it be studied in all its bearings, if we do not take into consideration the physical laws which have governed its atmosphere from the beginning? The plants are the true recorders of atmospheric circumstances, and the fossil plants the documents, the hieroglyphs written and left in the strata of the earth for the interpretation of their laws. They have recorded them as clearly as it is done by the instruments used now, the thermometers, the barometers, the hygrometers, etc. Shall we not open the great book and try to read at least some of its pages, though they may have become obscured by the walk of time? And as all animal life depends on plants, the concordance of the development of both the vegetable and animal worlds, should not be forgotten when we come to consider the advantages which may be derived from the study of the coal flora of America. For, of course, these advantages cannot be derivable in such plenitude from an acquaintance with the vegetation of a single country. What has been discovered in Europe, from paleontological evidence, has to be either confirmed, or perhaps, presented under a new light, by what may be found on this continent.

The results of the researches on the remains of coal plants in this country, as far as they have now reached, may be already accounted creditable and valuable. They have proved the existence of land vegetation, as far down as the Upper Silurian period. They have settled the question of the existence of a marine vegetation in the true coal measures, where fucoidal remains, some of them referable to old types, have been discovered in Pennsylvania and Indiana. They have also positively established the fact of the existence of *Fungi* or Mushrooms at the epoch of the coal. But by far the more in-

interesting data procured refer to the discovery in our carboniferous measures of species of plants which have been until now considered in Europe as characteristic of more recent formations. Thus we have in the sub-carboniferous, under the Chester limestone of Illinois, leaves referable to the genus *Glossopteris*, as described by Brongniart, and remarkably similar to those of his *G. Nillsoniuna*. This genus, says Schimper, has no analogous in the present vegetation, and its existence appears limited to the first half of the Jurassic period. This is remarkable indeed ; and it might be supposed that though the specimens of this species are very clearly defined in their characters, they may represent a different and new type with a mere casual likeness. But we have at Morris, from the first coal above the millstone grit, a fine leaf of *Phlebopteris* (*Dictyophyllum*), preserved in its integrity, with its distinct characters, the peculiar nervation not remarked in any other genus. And this genus is also Liassic, for Europe at least. Beside this, the coal of Morris is related to the Permian of Europe by a number of identical types, a fact remarked already by Schimper. The species of *Spirangium*, for example, are not rare in the nodules of Mazon creek. From the sub-carboniferous of Alabama and of Pennsylvania we have two species of *Teniopteris*, a genus also considered in Europe as limited to the Permian. This enumeration might be pursued farther ; but the peculiarities of distribution will be better understood when accompanied by the description of species, and by the notes upon their relationships.

From the remarks made already it is easily understood that the documents concerning the geographical distribution of the species of the coal flora have been carefully searched for and recorded. They are already valuable for comparing the characters of the vegetation, not only in the different basins in North America, but of Europe also. To elucidate this question as far as possible stations, fixed at distant localities, and where long and persistent explorations have been pursued, are especially valuable. With the station of Newport, Rhode Island ; that of Cannelton, Pennsylvania ; of Morris, Illinois ; of Clinton, Missouri ; of Pomeroy, Ohio ; of two localities in the coal mines of Alabama, we may expect to find by comparison of the floras reliable documents in regard to the question of the horizontal or geographical distribution of the species.

The last and more important question refers to the stratigraphical distribution of the coal plants ; and to it belongs, as a postulate, that of the possibility of determining the relative horizons of the coal beds from the vegetable fossil remains possibly discovered in connection with them. This question has been for a long time, and is still, at issue among European paleontologists, who are generally inclined to admit that there is or should be a marked diversity in the floras of coal strata of different ages or of different horizons. Imbued with this persuasion I began researches in Pennsylvania with the idea that in a fair and open field like that of our carboniferous measures, which are exposed to exploration, sometimes for great thicknesses of strata, and besides, over very wide areas, a problem of this kind should be easily solved. My belief in the applicability of paleontology

to the identification of the coal beds was confirmed by the opinion of the miners, who, when questioned on the subject, generally asserted that it was for them an easy matter to tell one coal from another by comparing the roof shales, and their remains of plants. My first attempt to a determination of this kind, in connection with the first Geological Survey of Pennsylvania, was, as observed by Professor Lesley, a marked failure. For I considered the Salem vein of Port Carbon as the equivalent of the Mammoth, while these represent the two extremes of the Anthracite measures, one at the base, the other in the upper part. But paleontology is not accountable for a personal blunder, which, moreover, was forced upon me by peculiar circumstances which, if they do not make it excusable, at least explain it. I had found, back of the hill facing Port Carbon, just after passing the cut of the railroad entering Mill creek, large heaps of shale extremely rich in fossils, and had there made a prolonged search for the study of a well determined local flora, when I was informed by a miner that I should find opposite, and at the foot of Sharp Mountain, the same kind of shale with abundant specimens of the same plants. There, indeed, I found *Pecopteris arborescens*, an essentially characteristic species of the upper coal, with *Neuropteris Loschii*, and other species seen at the first locality; but with them were remains of *Lepidodendron*, of species of *Sigillaria* and of *Alephopteris*, which I had formerly recognized above St. Clair, in connection with the Mammoth vein. This seemed so extraordinary that I visited the same places many times on the supposition that I had been mistaken by false appearances in the characters of the plants; but the same evidence was always there; and I came to the conclusion that from all appearances, that coal of Port Carbon was the equivalent of the Mammoth, though differently placed by Professor Rogers. For all the coal beds along the valley of Mill creek are turned up vertically, and therefore, their relative position was at that time unascertained. It was only after years, that in my rambles around Pottsville, on revisiting again the heap of shales of Sharp Mountain, I was informed by the Superintendent of a coal mine whom I met in the vicinity, that these debris were from a tunnel pierced through a number of small veins including the upper ones, to reach the bottom vein, the Mammoth, which was found there too thin to be worked and had been abandoned. Therefore the remains of plants of a number of coal beds of different horizons were there mixed together. I do not say this in order to support an opinion which, in regard, at least, to the application of vegetable paleontology to the identification of coal strata, has been, by long experience, if not altered, at least reduced in the main. For I know well, now, how rarely remains of fossil plants are found in the same degree of profusion in connection with coal beds of the same horizon; how rarely, when these remains are found, they represent the same species, or, at least, have them in the same proportional distribution; and how careful and protracted the study of the flora of the same coal has to be before it is possible to know the peculiar species which may belong exclusively to it, or be considered as the leading ones. For this

knowledge includes, with the acquaintance of the greatest number of species recognized at a peculiar locality, that of their mode of dispersion over wide areas, or of the changes caused locally by the geographical distribution of the species. When the coal beds are, therefore, at great distances, it is not possible to leave off the idea that the modifications in the characters of the plants, if differences are observed, may have been caused as well by local synchronous influences as by a difference in the time of their formation or in their age. Nevertheless, I still believe that in basins of limited areas or for beds of coal of one and the same locality, the remains of plants in the roof shale may serve to identify the different strata, and may thus be used as a direction by the miners. But even in such cases the paleontological indications may fail or lead to mistakes; for the changes in the constituents of the roof shales are often sudden and remarkably varied. The Cook vein of Western Kentucky, for instance, has in its shale a profusion of remains of *Lepidodendron* and *Lepidostrobus* on one side of the main gangway, while on the other it is transformed into a kind of compact bone or cannel coal with no other fossils but small shells.

When the subject of the vertical distribution of the vegetation of the coal is considered *a priori*, it seems rational to admit that the same vegetable types cannot have been persistent for such a period of time as was necessary not only for the growth and accumulation of the plants which have entered into the composition of a coal bed from six to ten feet thick, or more, but for the heaping of the intercalated strata, sandstone, limestone, shale, etc., which sometimes measure hundreds of feet in thickness. The study of the floras of our time does not afford us any data in regard to the duration of vegetable types. The human races are still too young, or at least the records of the present vegetation do not yet reach far enough to afford evidence of the modification of any species of plants. We have, however, positive facts in the more recent geological times which prove a remarkable degree of persistence in the characters of a flora for a distance of time, as indicated by interstratified formations, still longer than it may be supposed necessary for the production of two coal beds, and hundreds of feet of shale, sandstone, etc. between them. In the Tertiary of the Rocky Mountains, strata bearing plants in connection with lignites have been found at Point of Rocks, Wyoming Territory, and a number of identical species, indeed, a flora bearing the same general characters, is exposed, also with lignite beds, at Black Butte, though the two localities are separated by three to four thousand feet of measures, shale, sandstone, lignite beds, etc. If these lignite floras had been considered separately and without evidence of the distribution of the intervening measures, they would have been admitted as evidently synchronous, or as representing the same horizon. Hence the long persistence of vegetable types is a fact which has to be recognized by paleontologists although it may be contradictory to theoretical considerations.

The modifications in the characters of the plants are recognized, however, in the flora of the Carboniferous; but they have been slow, tran-

sitional, and affecting essentially the general features of periods. They give to separate groups a peculiar character, which may serve to separate them. In a lot of plants sent by Prof. Eug. Smith from Alabama, for example, I found such a dissimilarity of typical forms from those of the coal measures of the north, and also such an affinity with those of the Arkansas sub-carboniferous flora, that this relation forcibly referred both to the same period.

The distinctive characters of the groups of the Carboniferous can be only briefly exposed now; but they are to be more positively fixed in the Flora by separate tables indicating all the species of plants which have been recognized in each of them. This will prove an interesting representation of the distribution of the vegetation of the coal, not merely by the number of species, but especially as a kind of scale marking the progress in the modification either by disappearance of some types, or by their reproduction under different characters.

The groups as recognized until now are the Catskill, or old red; the Pseudo-carboniferous; the Sub-carboniferous, or Vespertine, limited upwards by the millstone grit; the Lower Carboniferous, up to the Pittsburgh coal; and the Upper Carboniferous, above it.

A few species of small Lycopodiaceous plants of the genus *Psilophyton* (Daws), appear first in the upper Silurian, and continue, by modifications of size especially in the Devonian, where four species are recognized. I consider this genus as representing the only Devonian type which does not pass up into the Carboniferous. There may be some others, however, as indicated by fossil wood: *Dadoxylon*, *Syringoxylon*, *Prototaxites*, etc. But the anatomy of the fossil wood of the whole Carboniferous is not yet advanced enough to allow conclusions on the characters of the vegetation represented by fossil trunks. Prof. Dawson is still pursuing with an industrious energy his researches on this difficult subject, which, to my regret, has remained inaccessible to me for want of materials. For except the fossil wood of the Black Devonian shale of Ohio, no specimen of silicified vegetable organism has been discovered in coal measures of the United States, except the numerous stems of fern trees of Southern Ohio. These might give materials enough for the work and studious application of a whole life.

The more notable characteristic type of the Catskill group is that of the ferns described first under the generic name of *Næggerathia*, and more recently of *Palæopteris* and *Archæopteris*. The species are represented by large fronds; those of the older type with simple leaflets more or less enlarged upwards from a narrowly cuneate, somewhat decurring base, whose veins are straight and diverging, fan-like, merely by sub-divisions. The forms of the leaflets are very variable; some appear nearly linear and merely thinly lined with parallel veins. These, however, pass to the genus *Cordaitea*, which is present in the whole flora of the coal measures. The modifications of *Psilophytum* are possibly represented in the Catskill by a few species of *Lepidodendron*. *Calamites*, *Annularia* and *Asterophyl-*

lites have there, also, some rare representatives. In the Pseudo-carboniferous, characterized as it is now by the species published by Prof. Andrews, from the Waverly Sandstone of Ohio, and those determinable from the specimens from Port Byron, Ill., the *Paleopteris* continues to be present. But some of the species have lobed or decomposed leaflets, tending by these characters to a section of the *Sphenopteris*, which comes later. The predominant forms are those of *Megalopteris*, a splendid fern whose advent is not prefigured in the flora of the Catskill by any species known until now. But in its large leaflets and its nervation, it evidently betokens the great family of the *Neuropteridæ* to which belong the most beautiful and varied forms of the coal plants. The same rock group has rare species of *Alethopteris*, also with very large fronds and leaflets, *Hymenophyllites*, and broadly winged fruits of the genus *Cardiocarpon*. One species of *Paleopteris*, similar to *P. obtusa*, is remarked in this division as well as in the Catskill group. And on another side it has some species of *Lepidodendron*, *Lepidophloios*, a small *Asterophyllites*, etc., which continue higher up, and enter the sub-carboniferous measures. We have as yet too little data in regard to the flora of the Catskill, and that of the Pseudo-carboniferous to be able to positively recognize the points of affinities and of difference. Most of the species have been described from Canada and Maine, and their age generally ascribed to the Devonian, or marked under the indefinite appellation of pre-carboniferous. The flora of the sub-carboniferous division is, *per contra*, known by a large number of its species. It is allied to the pseudo-carboniferous by those which are named above; by species of *Sphenopteris*, *Triphylopteris*, *Eremopteris*, and especially of *Alethopteris*, of analogous types. It has for its own predominant characters some *Neuropteris*, with large fronds and small leaflets as *N. Smithii*, which though extremely abundant in Alabama and Virginia, has not as yet been discovered in the coal measures above the Millstone grit; *Neuropteris tenuifolia*, which persists even to the highest strata of the coal, is there also. Professor Fontaine has seen in the Vespertine of Virginia species of *Odontopteris*, a genus predicted by the fine *Eremopteris marginata* of the pseudo-carboniferous. This one partakes of the *Odontopteris* type, quite as much as of the *Eremopteris* character, recalling also something of the facies of *Megalopteris*, which has not been seen in the sub-carboniferous until now. In this last division, the number of species is, as stated, greatly multiplied, and it becomes now difficult to positively mark those which are limited to it. The *Lepidodendron*, especially, are extremely abundant. The old types *L. Sternbergii*, *L. Veltheimianum*, *L. aculeatum*, etc., appear mixed with more recent ones, and with others which seem peculiar to this division: as *L. squamiferum* from the Helena vein of Alabama, which bears upon its bark true scales, easily detached, and at the same time, the scars of leaves generally remarked upon the trunks and branches of *Lepidodendron*. The collateral genera are represented also: *Ulodendron*, *Halonina*, *Lepidophloios*, *Knorria*; *Stigmaria* is there in abundance, though remains of *Sigillaria* are as yet extremely rare. Among the

species which have been considered in Europe as characteristic of the Mountain Limestone of the culm, we have in the sub-carboniferous of Alabama and Virginia *Alethopteris nervosa*, *A. muricata*, and *Sphenopteris Hæninghausii*, this as common in the shale of the Helena coal as *Neuropteris Smithii*. These three species, however, ascend in the American coal measures to above the Millstone grit, which, though a kind of geological delimitation, as well traced here as in Europe, is not a very definite line of demarcation between the vegetable groups. For, with few exceptions, the lower carboniferous flora has still the types of the sub-carboniferous, merely modified, and represented by an increased or diminished number of species. The Lycopodiaceous are still more abundant; and we have, especially in the lower veins, immediately above the Millstone grit, the largest number of species of *Lepidodendron* and *Ulodendron*. *Stigmaria* and *Sigillaria* have gained in predominance; and in the ferns, new species of *Neuropteridæ*, especially some large-leaved *Neuropteris* and *Odontopteris*, are seen for the first time. The wide-ranged *Alethopteris Serlii*, and its analogous species *A. lonchitica*, are there also; the first already seen in the sub-carboniferous, the second a derivation of *A. Helenæ*, of the same lower division. *A. Pennsylvanica* and *A. Sullivantii*, may be counted too in the first coal above the conglomerate, as prefiguring in their more important characters those of the *Callipteris*, which comes later in order of time. For one species of this last genus only is known in the lower carboniferous, and another from the Cannelton coal, already somewhat high up in the measures. As the largest number of the species of plants of the coal have been obtained from the lower carboniferous, it would be possible to continue the enumeration of the species which are considered as proper to it or as characteristic. But subsequent researches may greatly reduce the number; for as yet few strata bearing remains of plants have been discovered in the upper carboniferous. This division may be limited from the base or from the top of the barren measures underlying the Pittsburgh coal; for indeed we know as yet nothing of the flora of these barren strata. In ascending from the Millstone grit, after passing the two first coal beds above it, the vegetation is rapidly modified in its characters by the gradual disappearance of the Lycopodiaceous types, and the increasing predominance of the ferns. The species of *Sigillaria* continue in about the same proportion; *Annularia*, *Sphenophyllum*, *Asterophyllites*, become more abundant. And while some of the generic divisions of the ferns, like *Alethopteris* and the large-leaved *Pecopteris*, seem to pass away; the group of the *Cyatheæ*, represented by *Pecopteris arborescens*, *P. oreopteridia*, *P. polymorpha*, etc., become the more numerous, and especially characterize the upper carboniferous. They mostly belong to tree ferns, which, besides the extreme abundance of their pinnæ in the highest veins of Pennsylvania, have left, petrified in the sandstone of Ohio and Virginia a prodigious quantity of trunks representing whole forests. With these there is no trace of *Lepidodendron*; some *Sigillaria* are left. The vegetable world was at that period a world of ferns, mixed with the *Corduites*, a race of as yet undetermined relation, it seems, half-lycopodia-

ceous, half conifers. These plants are mostly known by their long linear, ribbon-like leaves; their stems have been very rarely found. Some large, bushy species of *Neuropteris* have persisted. *N. hirsuta* and *N. Loschii* ascend from the Millstone grit to the Permian. And above the Pittsburgh coal or even in connection with it are found the *Callipteris*: *Callipteris Moorii*, and *Callipteris conferta*, this last species one considered in Europe as Permian, and found by the Virginian geologists, Fontaine and White, in the highest strata of the carboniferous. We have seen, however, that many other so-called Permian types are remarked in the American coal measures already from below the millstone grit; and therefore, it is not as yet advisable to consider as Permian those upper strata which, beside this *Callipteris*, have a number of representations of truly carboniferous species.

It remains only to state how far the work on the American coal flora has progressed towards its completion. The plates, sixty in number, are all ready. The number might be still further increased by several species which cannot be clearly represented by descriptions only; but wood cuts may be used for the purpose, if it is advisable and possible to have any intercalated into the text. The description of the species and the remarks upon their diversified characters, as seen in the comparison of the specimens, have been all written, and, therefore, the manuscript may be definitely prepared in a short time. It is, however, not yet in its final shape, as the records have to be left open for the admission of any valuable data which the continued communications of materials may bring to the Flora.

This synopsis is very incomplete, but it cannot be made comprehensible without the tables of distribution, even if a large number of species were enumerated. Moreover the limitation of the vegetable groups is not yet definite enough. New and indeed very desirable discoveries, especially of plants of the Lower Carboniferous, the Vespertine of Pennsylvania, and the Devonian Hamilton Coal Measures of the Juniata, may compel important modifications. Therefore, the divisions as marked above, as well as their names, should be considered only temporary. They are subject, of course, to geological evidence which ought to govern them. The final nomenclature of the groups of the "Coal Flora" must accord with that of the Second Geological Survey of Pennsylvania.